By Express Mail # EL831449175US

JC18 Rec'd PCT/PTO 28 DEC 2001

FORM PTO-1390 (REV 10-94)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

DOCKET #: 502901-118PUS

				U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
				10/019516
INTERNATIONAL APPLICATION NO.		INTERNATIONAL FILING DATE		PRIORITY DATE CLAIMED
PCT/DE00/02157		30 June 2000		01 July 1999

TITLE OF INVENTION

System and Method for Producing and/or Treating a Fuel, Especially a Fuel for a Fuel Cell

APPLICANT(S) FOR DO/EO/US

Karl ECK; Wolfgang HERDEG; Holger KLOS; Martin SATTLER; Thomas ZAPP; Jürgen HABRICH; Markus KEUTZ; Franz REICHENBACH; Hans-Dieter WILHELM

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x]This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [x]This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x]A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x]A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x]is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.
8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. Below concern other document(s) or information included:

11. [] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x]A **FIRST** preliminary amendment.
    [] A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. [] A substitute specification.
15. [] A change of power of attorney and/or address letter.
16. [x]Other items or information *(specify):* PCT Publication Sheet, Int'l Preliminary Examination Report, Written Opinion, Int'l Search Report, PCT Request, Letter with Proposed Drawing Changes, Notification of Recording of a Change

By Express [illegible] 31449175US

JC13 Rec'd PCT/PTO 28 DEC 2001

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/019516	PCT/DE00/02157	502901-118PUS

17.[x]The following fees are submitted:		
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO ..... **$890.00** International preliminary examination fee paid to USPTO (37 CFR 1.482)..... **$710.00** No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))..... **$740.00** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... **$1040.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$	890.00
Surcharge of **$130.00** for furnishing the oath or declaration later than [] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	130.00

Claims	Number Filed	Number Extra	Rate		
Total Claims	16 - 20 =	0	x **$18.00**	$	-0-
Independent Claims	2 - 3 =	0	x **$84.00**	$	-0-
Multiple dependent claim(s) (if applicable)			+ **$280.00**	$	-0-
			TOTAL OF ABOVE CALCULATIONS =	$	1020.00
Reduction of ½ for filing by small entity, if applicable.				$	-0-
			SUBTOTAL =	$	1020.00
Processing fee of **$130.00** for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	-0-
			TOTAL NATIONAL FEE =	$	1020.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by the appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	-0-
			TOTAL FEES ENCLOSED		$1020.00
			Amount to be refunded:		$
			charged:		$

a. [x] One check in the amount of $1020.00 to cover the above fees is/are enclosed.

b. [] Please charge my Deposit Account No. 03-2412 in the amount of $____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-2412. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
Thomas C. Pontani
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551 Fifth Avenue, Suite 1210
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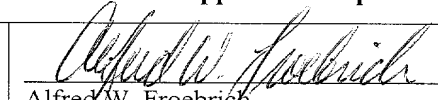

Alfred W. Froebrich
Registration Number: 38,887 December 28, 2001
Tel: (212) 687-2770

By Express Mail # EL831449175US · December 28, 2001

Attorney Docket # 502901-118PUS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re National Phase PCT Application of

Karl ECK et al.

International Appln. No.: PCT/DE00/02157

International Filing Date: 30 June 2000

For: System and Method for Producing and/or Treating a Fuel, Especially a Fuel for a Fuel Cell

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
BOX PCT

S I R:

Prior to examination of the above-identified application please amend the application as follows:

In the Specification:

Please delete the subtitle on page 1, line 5, and insert the following subtitles:

--BACKGROUND OF THE INVENTION

1. Field of the Invention--

Please insert at page 1, line 10, the following subtitle:

--2. Description of the Related Art--

Please insert at page 3, line 1, the following subtitle:

--SUMMARY OF THE INVENTION--

Please replace the paragraph beginning at page 3, line 1, with the following rewritten paragraph:

--An object of the present invention is to improve a system for producing and/or treating a fuel, especially the fuel for a fuel cell, which overcomes the problems of the prior art. In particular, a system is to be provided in which individual reactor elements can be cooled or heated in a simple design at favorable cost. Another object of the present invention is to provide a process for cooling or heating individual reactor elements.--

Please delete the paragraph beginning at page 4, line 11, in its entirety.

Please replace the paragraph beginning at page 6, line 2, with the following rewritten paragraph:

--It is advantageous to design the minimum of one heating/cooling unit as a heat exchanger in the form of a cooling coil and/or a cooling jacket. The heating/cooling unit can be

designed in any desired way as a function of the requirements and the concrete application and especially as a function of the amount of heat to be absorbed and released. If a large amount of heat is to be absorbed, it is advisable for the heating/cooling unit to have a large surface area in the reactor element. The heating/cooling units can be located in the surface area of the reactor elements or inside the reactor elements in any way desired, depending on the requirements. The invention is not limited to specific designs for the heating/cooling units.--

Please delete the paragraph beginning at page 7, line 18, in its entirety.

Please replace the paragraph beginning at page 8, line 20, with the following rewritten paragraph:

--The present invention is not limited to specific types of fuel cells, which means that the invention can be used in conjunction with any suitable type of fuel cell,. These fuel cells include, for example, alkaline fuel cells (AFCs), proton-conducting fuel cells or polymer electrolyte membrane fuel cells, phosphoric acid fuel cells (PAFCs), molten carbonate fuel cells (MCFCs), and solid oxide fuel cells (SOFCs).--

Please insert at page 9, line 6, the following subtitle:

--BRIEF DESCRIPTION OF THE DRAWINGS--

Please replace the paragraph beginning at page 9, line 10, with the following rewritten paragraph:

-- -Figure 2 shows another embodiment of the system according to the invention for producing and/or treating a fuel.--

Please insert at page 9, line 12, the following subtitle:

--DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS--

Please replace the paragraph beginning at page 10, line 3, with the following rewritten paragraph:

--To heat or cool the individual reactor elements, a heating/cooling device 16 is provided. The heating/cooling device 16 consists of a series of heating/cooling units 20, each of which is designed as a heat exchanger in the form of coiled tubes 21 (shown only in the heating/cooling unit 20 of the selective oxidation reactor 14) inside the reactor elements and/or a cooling jacket (i.e., the heating/cooling unit 70 of the evaporator). The individual heating/cooling units are connected to each other via a flow conductor 17. As can be seen from the Figure, the flow conductor 17 and the individual heating/cooling units are designed to form a closed circuit. In the closed circuit of the heating/cooling device 16, a suitable heating/cooling medium is provided. In the present case, the medium is a highly heat-resistant oil. A pump 18 is provided in the flow conductor 17 so that the flow rate of the oil can be adjusted as desired.--

Please delete page 15 in its entirety.

In the Claims:

Please delete claims 1-13 and add new claims 14-29 as follows:

--14. (New) A system for at least one of producing and treating a fuel for a fuel cell, comprising:

at least one heat sink reactor element functioning as a heat sink;

at least one heat source reactor element functioning as a heat source, the fuel flowing through said at least one heat sink reactor element and said at least one heat source reactor element;

a heating/cooling device including a plurality of heating/cooling units, wherein each of said at least one heat sink reactor element and said at least one heat source element comprises one of said plural heating/cooling units; and

a flow conductor connecting each of said heating/cooling units for transporting heat therebetween via a heating/cooling medium.--

--15. (New) The system of claim 14, wherein said flow conductor and said plural heating/cooling units are connected such that they form a closed circuit.--

--16. (New) The system of claim 14, wherein said heating/cooling medium comprises highly heat-resistant oil.--

--17. (New) The system of claim 14, further comprising at least one pump installed in said flow conductor.--

--18. (New) The system of claim 14, wherein at least one of said plural heating/cooling units comprises a heat exchanger having a coil of tubing.--

--19. (New) The system of claim 14, wherein at least one of said plural heating/cooling units comprises a cooling jacket.--

--20. (New) The system of claim 14, wherein said at least one heat sink reactor element comprises an evaporator.--

--21. (New) The system of claim 20, wherein said at least one heat source reactor element comprises at least one of a shift reactor and a reactor for selective oxidation.--

--22. (New) The system of claim 21, further comprising a reformer arranged between said at least one heat sink reactor and said at least one heat source reactor.--

--23. (New) The system of claim 22, wherein a flow of fuel through said system proceeds from said at least one heat sink reactor element to said at least one heat source reactor element.--

--24. (New) The system of claim 14, wherein a flow of fuel through said system proceeds from said at least one heat sink reactor element to said at least one heat source reactor element.--

--25. (New) The system of claim 14, further comprising a reformer arranged between said at least one heat sink reactor and said at least one heat source reactor.--

--26. (New) The system of claim 14, wherein said at least one heat source reactor element comprises at least one of a shift reactor and a reactor for selective oxidation.--

--27. (New) A method for at least one of treating and producing fuel for a fuel cell in a system having at least one heat sink reactor element functioning as a heat sink, at least one heat source reactor element functioning as a heat source, and a heating/cooling device including a plurality of heating/cooling units, wherein each of the at least one heat sink reactor element and the at least one heat source element comprises one of the plural heating/cooling units and a flow conductor connects each of said heating/cooling units for transporting heat therebetween via a heating/cooling medium, said method comprising the steps of:

(a) conducting a flow of the fuel through the at least one heat sink reactor element and the at least one heat source reactor;

(b) adjusting a process temperature in each of the at least one heat sink reactor element and the at least one heat source reactor element by absorbing heat produced in the heating/cooling unit of the at least one heat source reactor element, transporting the absorbed heat via the flow conductor, and releasing the absorbed heat in the at least one heat sink reactor element.--

--28. (New) The process of claim 27, wherein said step of adjusting comprises conducting a heating/cooling medium through the flow conductor in a closed circuit.--

--29. (New) The process of claim 28, further comprising a pump in the flow conductor, wherein said step (b) further comprises regulating a flow rate of the heating/cooling medium in the flow conductor by the pump.--

IN THE ABSTRACT

Please delete the Abstract and insert the "Abstract of the Disclosure" attached hereto.

IN THE DRAWINGS

Please enter the drawing changes in the attached Letter with Proposed Drawing Changes.

REMARKS

The specification has been amended to add headings to place the application in better form for examination. Newly submitted claims are believed to comply with 35 U.S.C. §112. No new matter has been added.

Early consideration and action on the merits are solicited.

Any additional fees or charges required at this time in connection with the application may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
COHEN, PONTANI, LIEBERMAN & PAVANE

By: _____

Alfred W. Froebrich
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28 December 2001

By Express Mail # EL831449175US · December 28, 2001

AMENDMENTS TO THE SPECIFICATION AND CLAIMS SHOWING CHANGES

In the Specification:

The paragraph beginning at page 3, line 1, has been amended as follows:

--[Proceeding from the state of the art indicated above, the task] An object of the present invention is to improve a system for producing and/or treating a fuel, especially the fuel for a fuel cell, which overcomes the problems of the prior art [of the type indicated above in such a way that the disadvantages mentioned are avoided]. In particular, a system is to be provided in which individual reactor elements can be cooled or heated in a simple design at favorable cost. [A correspondingly improved process is also to be provided.] Another object of the present invention is to provide a process for cooling or heating individual reactor elements.--

The paragraph beginning at page 6, line 2, has been amended as follows:

--It is advantageous to design the minimum of one heating/cooling unit as a heat exchanger in the form of a cooling coil and/or a cooling jacket. The heating/cooling unit can be designed in any desired way as a function of the requirements and the concrete application and especially as a function of the amount of heat to be absorbed and released[,]. If a large amount of heat is to be absorbed, it is advisable for the heating/cooling unit to have a large surface area in the reactor element. The heating/cooling units can be located in the surface area of the reactor elements or inside the reactor elements in any way desired, depending on the requirements. The invention is not limited to specific designs for the heating/cooling units.--

The paragraph beginning at page 8, line 20, has been amended as follows:

--The present invention is not limited to specific types of fuel cells, which means that the invention can be used in conjunction with any suitable type of fuel cell,. These fuel cells include, for example, alkaline fuel cells (AFCs), proton-conducting fuel cells or polymer electrolyte membrane fuel cells (PEMFCs [[*polymer electrolyte membrane fuel cells - Tr. Ed.*]]), phosphoric acid fuel cells (PAFCs), molten carbonate fuel cells (MCFCs), and solid oxide fuel cells (SOFCs)[, and the like].--

The paragraph beginning at page 9, line 10, has been amended as follows:

-- -Figure 2 [[*not included in foreign document -- Tr. Ed.*]] shows another embodiment of the system according to the invention for producing and/or treating a fuel.--

The paragraph beginning at page 10, line 3, has been amended as follows:

--To heat or cool the individual reactor elements, a heating/cooling device 16 is provided. The heating/cooling device 16 consists of a series of heating/cooling units [(not shown)] 20, each of which is designed as a heat exchanger in the form of coiled tubes 21 (shown only in the heating/cooling unit 20 of the selective oxidation reactor 14) inside the reactor elements and/or a cooling jacket (i.e., the heating/cooling unit 70 of the evaporator). The individual heating/cooling units are connected to each other via a flow conductor 17. As can be

seen from the Figure, the flow conductor 17 and the individual heating/cooling units are designed to form a closed circuit. In the closed circuit of the heating/cooling device 16, a suitable heating/cooling medium is provided. In the present case, the medium is a highly heat-resistant oil. A pump 18 is provided in the flow conductor 17 so that the flow rate of the oil can be adjusted as desired.--

ABSTRACT OF THE DISCLOSURE

A system for producing and/or treating a fuel, especially hydrogen, for a fuel cells for the operation of a vehicle includes an evaporator functioning as a heat sink and two reactor elements functioning as heat sources in the form of a shift reactor and a reactor for selective oxidation. The evaporator and reactor elements are connected to each other by a line. A heating/cooling device with a heating/cooling unit for the evaporator and at least one heating/cooling unit for the shift reactor and the selective oxidation reactor is provided for heating/cooling the evaporator and reactor elements. The individual heating/cooling units are connected to each other by a flow conductor to form a closed circuit for the transport of heat. A suitable oil serving as a heating/cooling medium flows through the flow conductor. The system allows heat produced in the reactor elements to be absorbed by the corresponding heating/cooling units and transported via the flow conductor to the evaporator, where the heat is released via the corresponding heating/cooling unit.

2/pr

TRANSLATION:

WO 01/ 02,204 A1 PCT/DE00/02,157

SYSTEM AND METHOD FOR PRODUCING AND/OR TREATING A FUEL, ESPECIALLY A FUEL FOR A FUEL CELL

SPECIFICATION

The present invention pertains to a system for producing and/or treating a fuel, especially a fuel for a fuel cell, with at least one reactor element functioning as a heat sink and at least one reactor element functioning as a heat source. The invention also pertains to a method for producing and/or treating a fuel of this type.

Fuel cells have already been known for many years, and their importance has increased considerably in recent years, especially in the automotive industry.

Like battery systems, fuel cells generate electrical energy by chemical means, where the individual reactants are supplied continuously and the reaction product is removed, also continuously. The active principle by which the fuel cell operates is based on the ability of electrically neutral molecules or atoms to combine with each other and thus to exchange electrons. This process is referred to as the "redox" process. In a fuel cell, the oxidation and reduction processes occur in separate spaces. Then electrons released during reduction can be conducted as a current through the load, which can be, for example, an electric motor in an automobile.

The gaseous reaction partners which can be used in a fuel cell include, for example, hydrogen as the fuel and oxygen as the oxidizing agent. The oxygen can simply be taken from

the indrawn surrounding atmosphere, whereas the hydrogen must usually be produced by a chemical process. This is achieved, for example, by the use of a reforming process or the like to convert hydrocarbons present in natural gas or methanol to a hydrogen-rich gas. It is also conceivable that hydrogen could be produced by a so-called "partial oxidation" (POX) process.

In all cases, the system required to produce and/or treat the fuel consists of a number of different reactor elements, which are connected to each other by appropriate lines, so that the fuel can flow through the individual reactor elements as it is being produced or treated.

Exothermic reactions, that is, reactions which release heat, take place in some of the reactor elements, whereas heat is required in other reactor elements. Until now, the conventional approach has been to provide each individual reactor element with its own heating/cooling unit. This heating/cooling unit produces the temperature required in the reactor element. In the case of reactor elements in which exothermic reactions take place, this means that the heat generated in the reactor elements is carried away by the heating/cooling units, whereas, in the reactor elements in which heat is required, this heat is provided by the heating/cooling units.

The heating and cooling of the individual reactor elements as done in the past, however, suffers from a series of disadvantages. For example, each reactor element must be heated or cooled individually and independently of the other reactor elements, which means that the system is complicated in its design and relatively expensive to produce. In addition, a large amount of energy is required for this type of heating and cooling. Finally, no use can be made of the heat generated in the reactor elements with exothermic reactions, which means that this heat is lost to the overall process.

Proceeding from the state of the art indicated above, the task of the present invention is to improve a system for producing and/or treating a fuel of the type indicated above in such a way that the disadvantages mentioned are avoided. In particular, a system is to be provided in which individual reactor elements can be cooled or heated in a simple design at favorable cost. A correspondingly improved process is also to be provided.

The task is accomplished according to a first aspect of the invention by an elaboration of the system described above for the production and/or treatment of a fuel, especially a fuel for a fuel cell, which is characterized in accordance with the invention in that a heating/cooling device is provided; in that the heating/cooling device consists of at least one heating/cooling unit for the minimum of one reactor element functioning as a heat sink and at least one heating/cooling device for the minimum of one reactor element functioning as a heat source; and in that the heating/cooling units are connected to each other by a flow conductor for the transport of heat.

In this way, the individual reactor elements can be either heated or cooled as required, without the need for each element to have its own separate heating/cooling device as was necessary in the past. Thus the invention is based among other things on the basic idea that the individual heating/cooling units of the reactor elements in question are connected to each other via a flow conductor in such a way that heat is transported between the individual heating/cooling units and thus between the individual reactor elements.

If the system for producing and/or treating the fuel has, for example, one or more reactor elements functioning as heat sources, exothermic reactions take place in these reactor elements, which means that heat is released there. This heat is released to the heating/cooling units in

question.

If the system also has at least one reactor element functioning as a heat sink, which means that this reactor element requires heat for the reactions taking place in it, the heat released by the reactor elements functioning as heat sources can be used to heat the reactor elements functioning as heat sinks. For this purpose, the heat from the heating/cooling unit for the minimum of one reactor element functioning as a heat source is transported to the heating/cooling unit for the minimum of one reactor element functioning as a heat sink and released to it. Thus the thermal energy which has been produced is not lost. As a result of the system according to the invention, the heat in the reactor elements with exothermic reactions can be absorbed and transferred to the reactor elements which require heat.

Preferred embodiments of the system according to the invention can be derived from the subclaims.

It is advantageous for the heating/cooling units to be connected to each other via the flow conductor in a closed circuit. As a result, it is possible to provide a heating/cooling device with an especially simple design, by means of which the required heat balances in the individual reactor elements can be easily controlled.

In another embodiment, a heating/cooling medium can be provided to flow through the heating/cooling units and the flow conductor. Via a heating/cooling medium of this type, the absorption or release of heat can be adjusted to precisely defined values. An advantageous heating/cooling medium is, for example, an oil, in particular a highly heat-resistant oil. Oils of this type are already known in the state of the art. The invention is not, however, limited to the use of oil as a heating/cooling medium. Other heating/cooling media in liquid or gaseous form

are also conceivable and possible. The only important point is that the selected heating/cooling medium must be capable of absorbing the heat generated in the individual reactor elements and of easily releasing it to the other reactor elements.

In a further embodiment, at least one pump can be provided in the flow conductor. Such a pump can be used to adjust the flow rate and throughput of the heating/cooling medium in the flow conductor and in the heating/cooling units. Via the flow rate of the heating/cooling medium, it is possible to regulate, among other things, the rate at which heat is absorbed or released by the heating/cooling medium.

The flow direction in the heating/cooling device is preferably set up to proceed from the minimum of one heating/cooling unit for the minimum of one reactor element functioning as a heat source to the minimum of one heating/cooling unit for the minimum of one reactor element functioning as a heat sink. In this way, the thermal energy can be transported from the minimum of one reactor element functioning as a heat source to the minimum of one reactor element functioning as a heat sink. When, for example, a heating/cooling medium is used, this medium heats up as it passes through the minimum of one reactor element functioning as a heat source and thus takes the heat along with it. As a result, the reactor element functioning as a heat source cools down. The heat which has been taken up is transported to the minimum of one reactor element functioning as a heat sink. There the heat is released, as a result of which the heating/cooling medium cools down. The heating/cooling medium which has now been cooled again is transported back through the flow conductor to the reactor elements functioning as heat sources, where it can absorb heat again. Because the number and connection of the individual reactor elements among themselves can be different depending on the need and the

concrete case, it is obvious that the flow direction could be set up in some other way.

It is advantageous to design the minimum of one heating/cooling unit as a heat exchanger in the form of a cooling coil and/or a cooling jacket. The heating/cooling unit can be designed in any desired way as a function of the requirements and the concrete application and especially as a function of the amount of heat to be absorbed and released,. If a large amount of heat is to be absorbed, it is advisable for the heating/cooling unit to have a large surface area in the reactor element. The heating/cooling units can be located in the surface area of the reactor elements or inside the reactor elements in any way desired, depending on the requirements. The invention is not limited to specific designs for the heating/cooling units.

In another embodiment, the minimum of one reactor element functioning as a heat sink can be designed as an evaporator. Such an evaporator is required, for example, when hydrogen is to be reformed from methanol or natural gas.

In a further embodiment, the minimum of one reactor element functioning as a heat source can be designed as a shift reactor and/or as a reactor for selective oxidation. These two reactor elements are required when the hydrogen is produced by the process of partial oxidation. Here the gas is purified by a homogeneous water gas reaction ($CO + H_2O \rightarrow CO_2 + H_2$) in the shift reactor and then ultrapurified in the following stage -- the stage of selective oxidation.

It is preferable to provide a reformer between the reactor functioning as a heat sink and the minimum of one reactor element functioning as a heat source.

In a further elaboration, the flow direction of the fuel can be set up to proceed from the minimum of one reactor element functioning as a heat sink to the minimum of one reactor element functioning as a heat source. In this case, the flow direction of the fuel is opposite the

flow direction of the heat transport through the heating/cooling device. Depending on the type and number of reactor elements used, it is also possible to provide a different flow direction.

According to a second aspect of the present invention, a process is provided for producing and/or treating a fuel, especially a fuel for a fuel cell, especially with the use of a system according to the invention as described above, where the fuel flows through at least one reactor element functioning as a heat sink and through at least one reactor element functioning as a heat source. The process is characterized according to the invention in that a suitable process temperature is adjusted in each of the reactor elements by means of a heating/cooling device, in that the heat produced in the minimum of one reactor element functioning as a heat source is absorbed by a heating/cooling unit, transported via a flow conductor to a heating/cooling unit for the reactor element functioning as a heat sink, and released to the reactor element.

By means of the process according to the invention, the goal is reached that the individual reactor elements do not have to be cooled in a complicated manner, nor is there any more loss of heat. Instead, the heat is easily transported from the reactor elements functioning as heat sources to the reactor elements in which heat is required. With respect to the advantages, effects, results, and functioning of the process according to the invention, reference is made to the entire content of the previous discussion of the system according to the invention.

Advantageous embodiments of the process can be derived from the subclaims.

It is preferable for a heating/cooling medium to flow through the heating/cooling units and the flow conductor.

In a further embodiment, the heating/cooling units and the flow conductor can be designed as a closed circuit, through which a heating/cooling medium flows.

It is advantageous for the flow rate of the heating/cooling medium in the heating/cooling units and in the flow conductor to be regulated by at least one pump.

It is preferable for the flow direction of the fuel to be opposite the direction of the heat transport between the heating/cooling units, but this is not the only possibility.

The system according to the invention described above and the process according to the invention can be used advantageously for the production and/or treatment of a fuel for a fuel cell for the operation of a motor vehicle.

Especially when the system is used for a motor vehicle, the system often consists of an evaporator (e.g., for methanol), a reformer, a shift reactor, and a reactor for selective oxidation. In this case, three of these four reactors (all but the reformer) are often at almost the same temperature level. An exothermic reaction takes place, that is, heat is released, in two of these reactors, namely, in the shift reactor and in the selective oxidation reactor. Conversely, heat is required in the evaporator. The heat which is required is provided by the heat recovered in the two other reactors.

A preferred area of application for the system and for the process is, for example, the area of motor vehicle drive systems. This offers at present a wide area of applications for fuel cells; but other areas are also conceivable. Examples include fuel cells for mobile devices such as computers and mobile telephones and even power plants. Fuel cell technology is also suitable for providing a decentralized supply of energy to houses, industrial plants, etc.

The present invention is not limited to specific types of fuel cells, which means that the invention can be used in conjunction with any suitable type of fuel cell. These fuel cells include, for example, alkaline fuel cells (AFCs), proton-conducting fuel cells (PEMFCs

[*polymer electrolyte membrane fuel cells - Tr. Ed.*]), phosphoric acid fuel cells (PAFCs), molten carbonate fuel cells (MCFCs), solid oxide fuel cells (SOFCs), and the like.

The system according to the invention for producing and/or treating a fuel can be applied, although not exclusively, to the production of hydrogen from, for example, methanol, methane, gasoline, natural gas, coal gas, sewer gas, etc.

The invention is now explained in greater detail on the basis of exemplary embodiments with reference to the attached drawing:

— Figure 1 is a schematic diagram of a first embodiment of the system according to the invention for producing and/or treating a fuel, especially a fuel for a fuel cell; and

— Figure 2 [*not included in foreign document -- Tr. Ed.*] shows another embodiment of the system according to the invention for producing and/or treating a fuel.

Figure 1 shows a system 10 for producing and/or treating a fuel, especially a fuel for a fuel cell. The fuel to be produced and/or treated is hydrogen in the present case.

The hydrogen is generated from a hydrocarbon-containing fuel in the system 10, which consists of a series of reactor elements, which are connected to each other by a line 15. These reactor elements comprise a series of units, namely, an evaporator 11, a reformer 12, a shift reactor 13, and a reactor for selective oxidation 14, which are arranged in the flow direction of the fuel or hydrogen in line 15 as indicated by the arrows.

In the evaporator 11, the fuel supplied as starting material (e.g., methanol) is first evaporated; heat is required for this process. The evaporator 11 is therefore a reactor element which functions as a heat sink. Exothermic reactions, however, take place, in the shift reactor 13 and in the selective oxidation reactor 14; that is, heat is produced here. To arrive at a

suitable temperature in these reactor elements, the heat which is produced must be carried away.

To heat or cool the individual reactor elements, a heating/cooling device 16 is provided. The heating/cooling device 16 consists of a series of heating/cooling units (not shown), each of which is designed as a heat exchanger in the form of coiled tubes inside the reactor elements. The individual heating/cooling units are connected to each other via a flow conductor 17. As can be seen from the figure, the flow conductor 17 and the individual heating/cooling units are designed to form a closed circuit. In the closed circuit of the heating/cooling device 16, a suitable heating/cooling medium is provided. In the present case, the medium is a highly heat-resistant oil. A pump 18 is provided in the flow conductor 17 so that the flow rate of the oil can be adjusted as desired.

The way in which the process for producing and/or treating hydrogen works will now be described.

During the production of hydrogen, thermal energy is required in the evaporator 11, whereas heat is produced in the shift reactor 13 and in the selective oxidation reactor 14 as a result of the exothermic reactions taking place in them. When now an oil circuit for heat transport as described above is provided in the heating/cooling device 16, which allows the oil to pass though the individual reactor elements one after the other, the thermal energy content of the reactor elements functioning as heat sources, namely, the shift reactor 13 and the selective oxidation reactor 14, can be transported to the reactor functioning as a heat sink, namely, the evaporator 11. The oil cooled by the evaporator 11 heats up as it passes through the selective oxidation reactor 14 and takes the heat along with it. The shift reactor 13 follows, which also

has the effect of heating the oil. After the shift reactor 13, the oil gives up the heat it has absorbed to the evaporator 11. Because the heating/cooling unit 16 is laid out as a closed circuit, this heat exchange can take place essentially without any losses.

The reformer 12 also required for the production of hydrogen in Figure 1 is installed between the evaporator 11 and the shift reactor 13; the reformer also requires heat, but heat at a different temperature level than that of the other reactor elements. Thus it is possible, for example, for the reformer 12 to require more heat than is produced and released by the exothermic reactions in the shift reactor 13 and in the selective oxidation reactor 14. For this reason, the reformer in the present case is not connected to the heating/cooling device 16, and thus the flow conductor 17 bypasses the area of the reformer 12.

As can also be seen in Figure 1, the flow direction of the fuel, which is shown by corresponding arrows in the line 15, is opposite the flow direction of the heating/cooling medium through the heating/cooling device 16, which is also indicated by appropriate arrows in the flow conductor 17.

Figure 2 shows another embodiment of the system 10 according to the invention for producing and/or treating a fuel. The elements which are designed in the same way as those in Figure 1 are designated by the same reference numbers.

The fuel is again produced or treated in the reactor elements, consisting of the evaporator 11, the reformer 12, the shift reactor 13, and the selective oxidation reactor 14, which are connected to each other by a line 15. The heating or cooling of the individual reactor elements is accomplished by way of the heating/cooling device 16. In the case of the exemplary embodiment according to Figure 2, however, the individual heating/cooling units in the various

reactor elements are connected by the flow line 17 in a different way.

When, for example, the temperature level of the selective oxidation reactor 14 is above the temperature level of the shift reaction taking place in the shift reactor 13 as a result of the use of a different catalyst, for example, it can be advisable to start up the shift reactor 13 first with the cold heating/cooling medium from the evaporator 11, this medium being supplied to the shift reactor 13 via the flow conductor 17 with the help of the pump 18.

In the shift reactor 13, the heating/cooling medium is heated as described above as a result of the exothermic reactions taking place. Then the heating/cooling medium is conducted through the heating/cooling unit of the selective oxidation reactor 14, where it heats up again. Then the hot heating/cooling medium is sent to the evaporator 11 to release its heat.

The system according to the invention is especially suitable for use in a vehicle to produce hydrogen in sufficient quantity and sufficient purity from a fuel in a tank (e.g., methanol or natural gas) while the vehicle is being driven, so that this hydrogen can be supplied as fuel to a fuel cell, which delivers the required electric current for the electric drive of this vehicle.

CLAIM(S)

1. System for producing and/or treating a fuel, especially a fuel for a fuel cell, with at least one reactor element (11) functioning as a heat sink and at least one reactor element (13, 14) functioning as a heat source, characterized in that a heating/cooling device (16) is provided; in that the heating/cooling device (16) has at least one heating/cooling unit for the minimum of one reactor element (11) functioning as a heat sink and at least one heating/cooling unit for the minimum of one reactor element (13, 14) functioning as a heat source; and in that the heating/cooling units are connected to each other for the transport of heat by a flow conductor (17) for a heating/cooling medium.

2. System according to Claim 1, characterized in that the heating/cooling units are connected to each other by the flow conductor (17) to form a closed circuit.

3. System according to Claim 1 or Claim 2, characterized in that a highly heat-resistant oil is provided as the heating/cooling medium.

4. System according to one of Claims 1-3, characterized in that at least one pump (18) is installed in the flow conductor (17).

5. System according to one of Claims 1-4, characterized in that the minimum of one heating/cooling unit is designed as a heat exchanger in the form of a coil of tubing and/or a cooling jacket.

6. System according to one of Claims 1-5, characterized in that the minimum of one reactor element functioning as a heat sink is designed as an evaporator (11).

7. System according to one of Claims 1-6, characterized in that the minimum of one

reactor element functioning as a heat source is designed as a shift reactor (13) and/or as a reactor for selective oxidation (14).

8. System according to one of Claims 1-7, characterized in that a reformer (12) is provided between the minimum of one reactor element (11) functioning as a heat sink and the minimum of one reactor element (13, 14) functioning as a heat source.

9. System according to one of Claims 1-8, characterized in that the flow direction of the fuel is set up to proceed from the minimum of one reactor element (11) functioning as a heat sink to the minimum of one reactor element (13, 14) functioning as a heat source.

10. Process for producing and/or treating a fuel, especially a fuel for a fuel cell, especially with the use of a system according to one of Claims 1-10, where the fuel flows through at least one reactor element functioning as a heat sink and at least one reactor element functioning as a heat source, characterized in that the process temperature in each reactor element is suitably adjusted by means of a heating/cooling unit, in that the heat produced in the minimum of one reactor element functioning as a heat source is absorbed by way of a heating/cooling unit and transported via a flow conductor for a heating/cooling medium to a heating/cooling unit for the reactor element functioning as a heat sink, where the heat is released to the reactor element.

11. Process according to Claim 10, characterized in that the heating/cooling medium is conducted through the flow conductor in a closed circuit.

12. Process according to Claim 10 or Claim 11, characterized in that the flow rate of the heating/cooling medium in the heating/cooling units and in the flow conductor is regulated by at least one pump.

13. Use of a system according to one of Claims 1-9 and/or a process according to one of

Claims 10-12 for producing and/or treating a fuel in a vehicle for a fuel cell for operating the vehicle.

ABSTRACT

A system (10) for producing and/or treating a fuel, especially hydrogen, for a fuel cell for the operation of a vehicle is described, which has an evaporator (11) functioning as a heat sink and two reactor elements functioning as heat sources in the form of a shift reactor (13) and a reactor for selective oxidation (14). The individual reactor elements (11, 13, 14) are connected to each other by a line (15). So that the individual reactor elements (11, 13, 14) can be cooled or heated easily and at low cost, a heating/cooling device (16) is provided according to the invention, which has a heating/cooling unit for the evaporator (11) and at least one heating/cooling unit for the shift reactor (13) and the selective oxidation reactor (14). The individual heating/cooling units are connected to each other by a flow conductor (17) to form a closed circuit for the transport of heat. A suitable oil serving as a heating/cooling medium flows through the flow conductor (17). By means of the system (10) according to the invention, the heat produced in the reactor elements (13, 14) is absorbed by the corresponding heating/cooling units and transported via the flow conductor (17) to the evaporator (11), where the heat is released via the corresponding heating/cooling unit.

(See Figure 1)

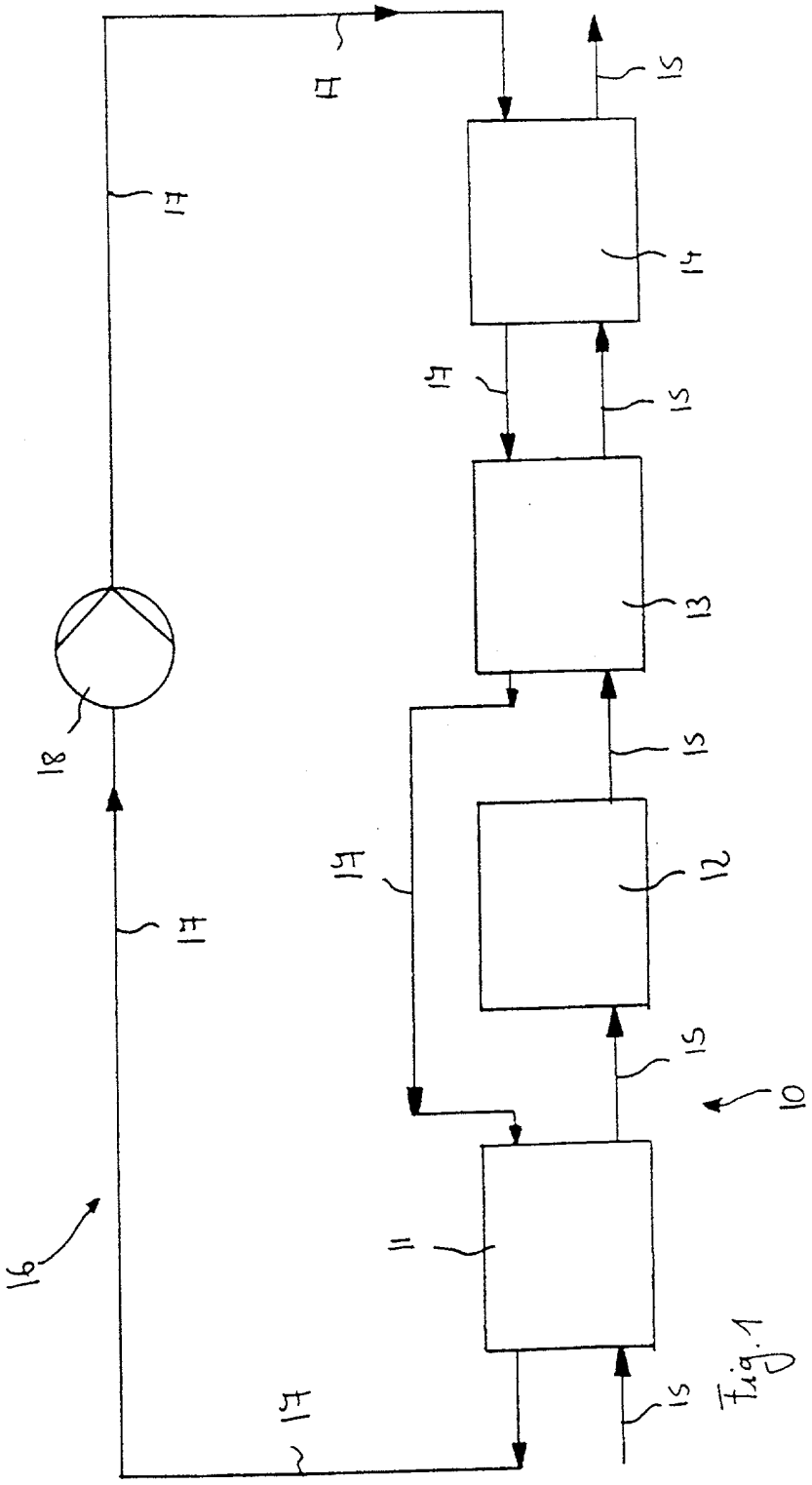

Fig. 1

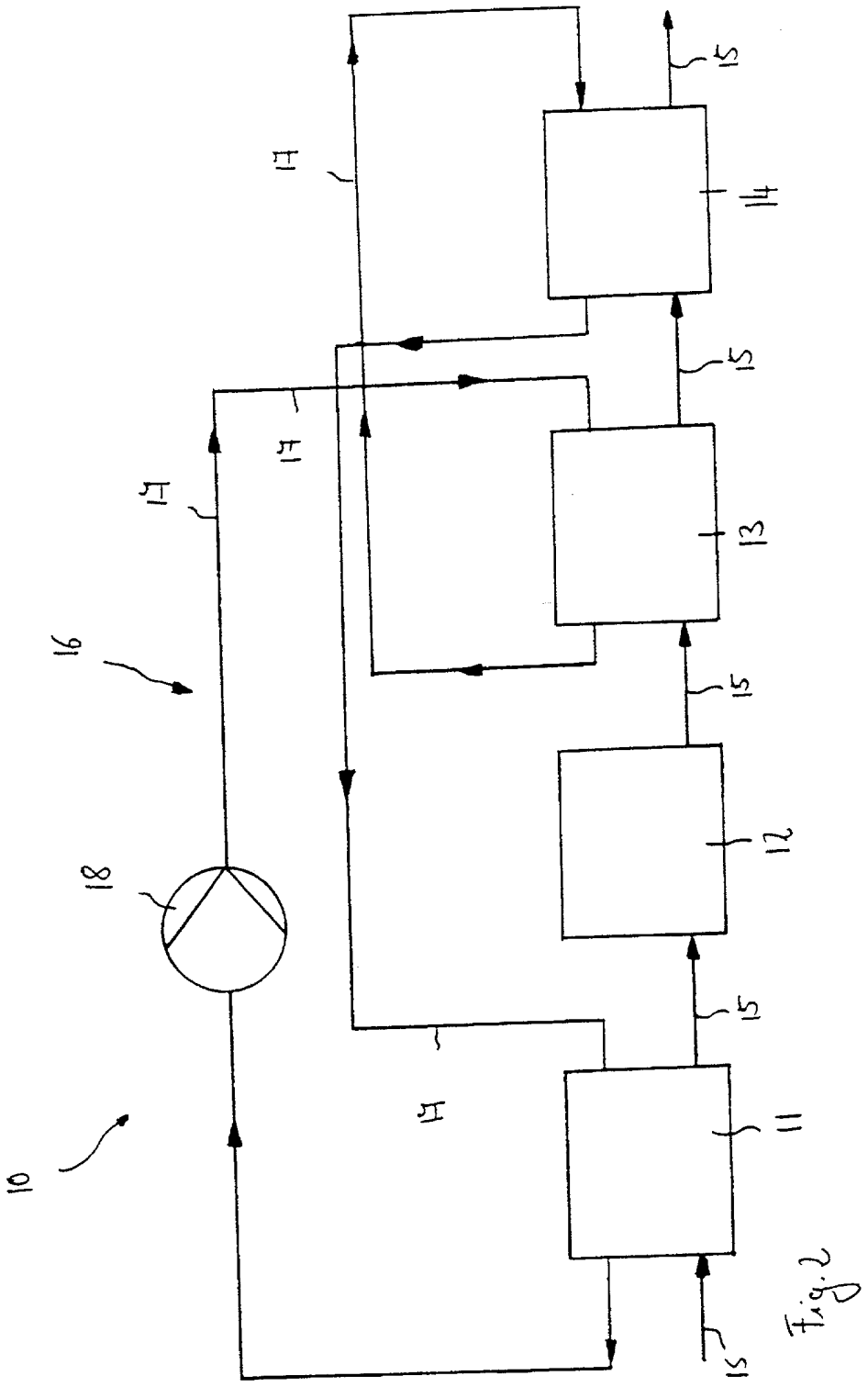

Fig. 2

List of Reference Numbers

10 = system for producing/treating a fuel

11 = evaporator

12 = reformer

13 = shift reactor

14 = selective oxidation

15 = line

16 = heating/cooling device

17 = flow conductor

18 = pump

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY Includes Reference to PCT International Applications	Attorney's Docket 502901-118PUS

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEM AND METHOD FOR PRODUCING AND/OR TREATING A FUEL, ESPECIALLY A FUEL FOR A FUEL CELL

the specification of which (check only one item below)

[ ] is attached hereto

[ ] was filed as United States application

Serial No.

On

And was amended

On __ (if applicable).

[x] was filed as PCT international application

Number PCT/DE00/02157

On 30 June 2000

And was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

PRIOR FOREIGN/PCT APPLICATIONS AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

Country (if PCT, indicate "PCT")	Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. 119	
Germany	199 31 064.5	1 July 1999	[X] YES	[ ] NO
PCT	PCT/DE00/02157	30 June 2000	[X] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO

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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS *(check one)*		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*			
PCT/DE00/02157	30 June 2000			x	

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*List name and registration number*)

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Attorney's Docket 502901-118PUS

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Attorney's Docket: **502901-118PUS**

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SIGNATURE OF INVENTOR 201 X	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
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DATE	DATE	DATE X 1/11/02

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209 = Wilhelm

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	Attorney's Docket: 502901-118PUS

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Dr. Hölig

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DATE	DATE	DATE

Dr. H. Klos

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DATE January 08, 2002	DATE	DATE
SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE

Sattler

Combined Declaration for Patent Application and Power of Attorney (Continued)
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502901-118PUS

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Dr. Zapp

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